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Fauna and Biogeography of the Bees and Wasps of the Cook Islands (Hymenoptera Aculeata)

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Abstract.—A total of 19 species of bees and aculeate wasps is currently known from the Cook Islands with six of them recorded for the first time: *Pison* spec. 2, *Sceliphron laetum* (F. Smith, 1856), *Ceratina* (*Neoceratina*) *dentipes* Friese, 1914, *Megachile* (*Eutricharaea*) spec. 1, *M.* (*E.*) spec. 2. The following three species are presumably indigenous: *Anterhynchium* (*Epiodynerus*) *rufipes* (Fabricius, 1775), *Parodynerus bicinctus* (Fabricius, 1781), *Tachysphex f. fanuiensis* Cheesman, 1928. Three more species are possibly indigenous but their status remains uncertain due to taxonomic problems: *Pison* spec. 1, *Pison* spec. 2, *Megachile* (*Eutricharaea*) spec. 1. A comparative analysis of faunistic data from other Pacific islands showed that the indigenous aculeate fauna of the Cook Islands is extremely depauperate. In general the number of species, especially parasitic taxa, and endemics decline from west to east with the remote archipelagos of Polynesia possessing the most depauperate aculeate faunas consisting only of widespread species.

Traditionally the oceanic Pacific islands are divided into Micronesia, Melanesia and Polynesia, originally on the basis of their indigenous aboriginal peoples, with the Cook Islands as a part of the latter (Crocombe 2001). Polynesia is a vast triangular area with the edges formed by Hawaii in the north, Easter Island (Rapanui) in the southeast and New Zealand in the southwest, including the territories of Hawaii, Kiribati (part), Tuvalu, Tokelau, Wallis & Futuna, Samoa, American Samoa, Tonga, Niue, Cook Islands, French Polynesia, Pitcairn, Easter Island and New Zealand (Crocombe 2001). Other than New Zealand, that has a continental origin, the islands of Polynesia are of volcanic origin. To colonize these isolated islands the terrestrial fauna and flora had to cross large areas of open ocean. Because only a small fraction of the bee and wasp species is capable of long distance dispersal (Michener 1979, 2000) the fauna derived from relatively few immigrants. As a result oceanic island faunas are usually depauperate. However, isolation and a highly diverse environment can lead to remarkable radiations, such as the 60 species of *Hylaeus* (*Nesoprosopis*) (Colletidae) and 99 *Odynerus* species (Vespidae) in the Hawaiian Islands (Nishida 1994, Daly and Magnacca 2003) and the endemic genus *Echthralictus* in Samoa (Michener 2000). Interestingly, endemic forms among the bees and wasps seem to have developed only on the high islands. The low coral atolls have only a sparse, introduced fauna derived mainly from the Oriental region (Krombein 1949b, 1950). Except for Hawaii (Nishida 1994, Daly & Magnacca 2003, Snelling 2003) and Samoa (Perkins and Cheesman 1928, Williams 1928) the bees and aculeate wasps of Polynesia are poorly studied (compilation in Williams 1947). It is the intention of his study to present the results of an investigation of the bees and aculeate wasps of the islands of Rarotonga and Mangaia made in 2004, including other available data about the Cook Islands. The biogeographic situation is discussed in

a Polynesian and Pacific context including a summary of data available for Pacific Islands.

MATERIALS AND METHODS

The Cook Islands consist of 15 islands located in the central South Pacific between the Society Islands to the east and Tonga and Samoa to the west. During a stay on the Cook Islands from 13th September to 7th October 2004 I collected on the two largest and most southerly of its 15 islands: Rarotonga with the capital Avarua (67 km^2) and Mangaia (51 km^2). Both have a tropical climate with Rarotonga being a geologically young (about 2 million years) high volcanic island (maximum elevation 653 m). The geologically old (about 18 million years) Mangaia is classified as a makatea island consisting of an uplifted karstified limestone rim encircling a central volcanic core (maximum elevation 169 m) (Hein et al. 1997). The specimens collected there are deposited in my collection. Reference material is located in the collections of various specialists (see acknowledgements). Additional records were taken from the Cook Islands Biodiversity Database (McCormack 2004). In the faunistic part families are in systematic, species in alphabetical order.

LIST OF WASPS AND BEES OF THE COOK ISLANDS

Chrysididae

Chrysis sp.

Distribution.—This unidentified species is known from Rarotonga (Totokoitu Research Station) and Atiu (McCormack 2004). Probably introduced.

Biology.— Cuckoo wasps of the genus *Chrysis* are known as parasites of a broad spectrum of aculeate wasps and bees (Kimsey 1990). The host of this species is unknown.

Specimens examined.—

Vespidae

Anterhynchium (*Epiodynerus*) *rufipes* (Fabricius, 1775)

Distribution.—Widespread in the Pacific region: Australia, New Guinea, Fiji, Tonga, Samoa, Tuvalu, Tokelau, Niue, Society Islands, Marquesas (Giordani Soika 1957, Carpenter, pers. comm.). Probably indigenous to the Cook Islands.

Previous records are from Rarotonga (1925, leg. G. Wilder; 1977, leg. Kraus, 1999), Atiu (1925, leg. G. Wilder; 1976, leg. Krauss) and Aitutaki (1960, 1976, leg. Krauss; Krauss 1961) but missing on Pukapuka (McCormack 2004). Probably present on most islands of the archipelago.

Biology.—The species can be regularly observed hunting or visiting flowers in gardens, along road sides and on fallow land. Two males from Mangaia carry some phoretic mites.

Specimens examined.—Rarotonga: Arorangi, fallow land, 10 m (21 12′54″S 159 49′42″W), 2 ♀, 19.ix.2004; Arorangi, upper beach, 5 m (21 12′45″S 159 49′39″W), 1 ♂, 21.ix.2004; 1 ♀, 4.x.2004; Mangaia: Ivirua, on Makatea, 30 m (21 55′15″S 157 53′21″W), 1 ♀, 1 ♂, 22.ix.2004; 3 ♀, 3 ♂, 27.ix.2004.

Delta esuriens okinawae Giordani Soika, 1986

Distribution.—The specimens correspond best to this subspecies that is known from China and Taiwan. It differs very little from typical *D. esuriens* from India and might be conspecific (Carpenter, pers. comm.). Introduced to the Cook Islands.

Previously known only from Rarotonga (Tupapa, xii.2002, leg. G. McCormack) (McCormack 2004).

Biology.—Species of *Delta* construct free clay nests on rocks, houses or wood and provision the cells with paralyzed caterpillars (Mader 2000).

Specimens examined.—Rarotonga: Arorangi, upper beach, 5 m (21 14′20″S 159 49′40″W), 1 ♂, 18.ix.2004; Mangaia: S Ivirua, on Makatea, 30 m (21 55′52″S 157 52′42″W), 1 ♀, 26.ix.2004.

***Pachodynerus nasidens* (Latreille, 1817)**

Distribution.—This species originated from the Neotropics and is now widespread throughout the Pacific region (Carpenter, pers. comm.). Introduced to the Cook Islands.

In the Cook Islands this species is very common and known from Rarotonga, Atiu, Aitutaki and Pukapuka (Krauss 1961, McCormack 2004). *P. nasidens* is probably present on most islands of the archipelago.

Biology.—The species can be regularly observed hunting or visiting flowers in gardens, along road sides and on fallow land, with a preference for the introduced Mexican Fire-plant (*Euphorbia cyathophora* J.A. Murray) (Euphorbiaceae).

Specimens examined.—Rarotonga: Arorangi, upper beach, 5 m (21 14′20″S 159 49′40″W), 1 ♀, 5 ♂, 15.ix.2004; 2 ♂, 18.ix.2004; Arorangi, fallow land, 10 m (21 12′54″S 159 49′42″W), 2 ♀, 5 ♂, 19.ix.2004; Arorangi, upper beach, 5 m (21 12′45″S 159 49′39″W), 1 ♀, 7 ♂, 20.ix.2004; 2 ♂, 21.ix.2004; 1 ♂, 4.x.2004; Mangaia: Ivirua, on Makatea, 30 m (21 55′15″S 157 53′21″W), 2 ♂, 22.ix.2004; Ivirua, Taro gardens, 30 m (21 55′20″S 157 53′53″W), 1 ♀, 1 ♂, 23.ix.2004; S Ivirua, on Makatea, 30 m (21 55′52″S 157 52′42″W), 1 ♂, 26.ix.2004.

***Parodynerus bicinctus* (Fabricius, 1781)**

Distribution.—Widespread in the Pacific region: New Guinea, Philippines, Fiji, Tonga, Tuvalu, Samoa, Cook Islands, Society Islands, Gambier Islands, Marquesas, Tuamotu Archipelago (Giordani Soika 1957, Carpenter, pers. comm.). Probably indigenous to the Cook Islands.

In the Cook Islands this species is very common and known from Rarotonga (1979, leg. Krauss), Atiu (1976, leg. Krauss), Mitiaro (1979, leg. ?Krauss) and Aitutaki (1977, leg. Krauss; Krauss 1961) but missing on Pukapuka (McCormack 2004). Probably present on most islands of the archipelago.

Biology.—This very common species can be regularly observed hunting or visiting flowers in gardens, along road sides and on fallow land, with preference for he introduced Mexican Fire-plant (*Euphorbia cyathophora* J.A. Murray) (Euphorbiaceae).

Specimens examined.—Rarotonga: Arorangi, upper beach, 5 m (21 14′20″S 159 49′40″W), 1 ♀, 15.ix.2004; 1 ♂, 18.ix.2004; Arorangi, fallow land, 10 m (21 12′54″S 159 49′42″W), 1 ♀, 19.ix.2004; Arorangi, upper beach, 5 m (21 12′45″S 159 49′39″W), 1 ♀, 7♂, 20.ix.2004; 1 ♀, 6 ♂, 21.ix.2004; 1 ♀, 2 ♂, 4.x.2004; Mangaia: Ivirua, Taro gardens, 30 m (21 55′20″S 157 53′53″W), 1 ♀, 1 ♂, 23.ix.2004; S Ivirua, on Makatea, 30 m (21 55′52″S 157 52′42″W), 1 ♀, 26.ix.2004; Ivirua, on Makatea, 30 m (21 55′15″S 157 53′21″W), 2 ♀, 5 ♂, 22.ix.2004; 2 ♀, 1 ♂, 27.ix.2004.

***Polistes jokahamae* Radoszkowski, 1887**

Distribution.—India, China, Mongolia, Korea, Japan, Taiwan, Society Islands, Tuamotu Archipelago; introduced to Hawaii (Carpenter 1996, as *P. jadwigae*). Probably introduced to the Cook Islands.

Previous records are from Rarotonga (iv.1925, leg. G. Wilder; xii.1977, Titikaveka, lowlands, leg. N.L.H. Krauss; xii.1977, Avarua lowlands, leg. N.L.H. Krauss, v.2002, Avana valley, leg. G. McCormack), Atiu (xi.1977, central plateau, leg. N.L.H. Krauss) and Aitutaki (ii.1960, leg. N.L.H. Krauss; xi.1977, Tautu, leg. N.L.H. Krauss; Krauss 1961) but missing on Pukapuka (McCormack 2004).

Biology.—This social paper wasp is ubiqitous in open habitats on the Cook Islands but less common than *P. olivaceus*. The species builds free hanging nests in bushes and trees.

Specimens examined.—Rarotonga: Arorangi, Raemaru trail, 50 m (21 14′06″S 159 49′19″W), 3 ♀, 17.ix.2004; Arorangi, upper beach, 5 m (21 12′45″S 159 49′39″W), 1 ♀, 20.ix.2004; Mangaia: Ivirua, on Makatea, 30 m (21 55′15″S 157 53′21″W), 3 ♀, 22.ix.2004; 4 ♀, 27.ix.2004; S Ivirua, on Makatea, 30 m (21 55′52″S 157 52′42″W), 1 ♀, 26.ix.2004.

Polistes olivaceus **(de Geer, 1773)**

Distribution.—East Africa, South Asia, Australia and common on archipelagos of the Indian and Pacific ocean (Carpenter 1996). Probably introduced to the Cook Islands.

Very common in the Cook Islands but missing in Tongareva (= Penrhyn) and Pukapuka (Krauss 1961, McCormack 2004).

Biology.—This social paper wasp is ubiqitous in open habitats on the Cook Islands and builds free hanging nests in bushes and trees.

Specimens examined.—Rarotonga: Arorangi, upper beach, 5 m (21 14′20″S 159 49′40″W), 7 ♀, 15.ix.2004; 1 ♀, 18.ix.2004; Arorangi, Raemaru trail, 50 m (21 14′06″S 159 49′19″W), 1 ♀, 17.ix.2004; Arorangi, fallow land, 10 m (21 12′54″S 159 49′42″W), 2 ♀, 19.ix.2004; Arorangi, upper beach, 5 m (21 12′45″S 159 49′39″W), 1 ♀, 20.ix.2004; 2 ♀, 4.x.2004; Mangaia: Ivirua, on Makatea, 30 m (21 55′15″S 157 53′21″W), 1 ♀, 22.ix.2004; S Ivirua, on Makatea, 30 m (21 55′52″S 157 52′42″W), 1 ♀, 26.ix.2004.

Ampulicidae

Ampulex compressa **(Fabricius, 1781)**

Distribution.—Ethiopia, Kenya, Tanzania, Arabian Peninsula, Madagascar, Seychelles, Réunion, Mauritius, India, Sri Lanka, Bangladesh, Singapore, south China, Indonesia, Philippines, Australia, New Caledonia (Pulawski 2003). To help control the cockroach *Periplaneta americana* (Linnaeus, 1758) between 1955 and 1958 its parasitoid *A. compressa* was introduced to Rarotonga from Hawaii, where it had been introduced from New Caledonia in 1941 (Walker & Deitz 1979, McCormack 2004). The conspicuous sphecid has not been observed for many years and might be extinct.

Biology.—All *Ampulex* species hunt cockroaches and nest in preexisting cavities (Bohart & Menke 1976).

Specimens examined.—

Sphecidae

Sceliphron caementarium **(Drury, 1773)**

Distribution.—The origin of this species is North and Central America, now ranging worldwide (Pulawski 2003). Introduced to the Cook Islands. Common on Rarotonga (McCormack 2004) and also present on Aitutaki (Krauss 1961).

Biology.—Species of *Sceliphron* construct free clay nests on rocks, houses or wood and provision the cells with spiders (Bohart and Menke 1976). This synanthropic species is common on Rarotonga where it can be frequently observed flying along walls and roofs even in the centre of the capital Avarua.

Specimens examined.—Rarotonga: Arorangi, fallow land, 10 m (21 12′54″S 159 49′42″W), 8 ♂, 19.ix.2004; Arorangi, upper beach, 5 m (21 12′45″S 159 49′39″W), 1 ♂, 20.ix.2004.

Sceliphron laetum **(F. Smith, 1856)**

Distribution.—India, Indonesia, New Guinea, Australia, New Zealand, Guam, Mariana Islands (Pulawski 2003). First record for the Cook Islands of this introduced species. Like other species of *Sceliphron S. laetum* is easily introduced to islands by ships. According to Krombein (1949b), this species accompanied a ship that sailed over 3,000 km from the Solomons to Guam in 1945 and established a colony there.

Biology.—Species of *Sceliphron* construct free clay nests on rocks, houses or wood and provision the cells with spiders (Bohart and Menke 1976). This species is less common on Rarotonga than *S. caementarium* and only known from one locality.

Specimens examined.—Rarotonga: Arorangi, fallow land, 10 m (21 12′54″S 159 49′42″W), 2 ♀, 2 ♂, 19.ix.2004.

Crabronidae

Pison **sp. 1**

Distribution.—About half of the 196 worldwide known species of the genus *Pison* occur in Australia and the Pacific

region with 26 of them known from Oceania (Pulawski 2003). The genus is badly in need of revision before the two species found on the Cook Islands can be identified. McCormack (2004) listed this bigger species as *P. tahitense* (de Saussure 1867) but it differs from it in the following points: mesopleuron sparsely punctate, with punctures several diameters apart (subcontiguous in *P. tahitense*), the propodeal posterior surface is punctate (transversely rugulosopunctate in *P. tahitense*) and the wings are translucent (moderately infumate in *P. tahitense*) (Pulawski pers. comm.). Krauss (1961) mentions *P. hospes* (F. Smith 1879) from Aitutaki. This species is known from Singapore, Philippines, New Guinea, Micronesia, Hawaii, Fiji, Tonga, Samoa, Marquesas and Society Islands (Yasumatsu 1953, Pulawski 2003). The two species I collected on Rarotonga and Mangaia, about 250 km south of Aitutaki, are clearly different from *P. hospes* (Pulawski pers. comm.). Due to the difficult taxonomic situation in this genus the identity of *P. hospes* reported by Krauss (1961) needs to be confirmed. Beside *P. hospes* and *P. tahitense* three more *Pison* species are known to occur in regions adjacent to the Cook Islands: *P. iridipenne* F. Smith, 1879 (Australia, New Guinea, Philippines, Hawaii, Micronesia, Fiji, Samoa, Society Islands, Tuamotu Archipelago, Marquesas), *P. ignavum* R. Turner, 1908 (Australia, New Guinea, Philippines, Taiwan, Micronesia, New Caledonia, Fiji, Samoa, Society Islands, Marquesas) and *P. impunctatum* R. Turner, 1912 (New Guinea, Society Islands, Marquesas) (Yasumatsu 1953, Pulawski 2003). The latter species was not available for comparison and the former two are different from the species collected (Pulawski pers. comm.). Both species collected during the survey are probably indigenous to the Cook Islands.

Previously known from Rarotonga (1999; iii.2003, leg. McCormack), Mangaia and Pukapuka (ii.2004, leg. McCormack) (McCormack 2004).

Biology.—Species of *Pison* construct either free clay cells or partitions holes in timber and provision the cells with spiders (Krombein 1949b).

Specimens examined.—Rarotonga: Arorangi, Raemaru trail, 50 m (21°14'06"S 159°49'19"W), 1 ♀, 17.ix.2004; Mangaia: S Ivirua, on Makatea, 30 m (21°55'52"S 157°52'42"W), 15 ♀, 26.ix.2004; Ivirua, on Makatea, 30 m (21°55'15"S 157°53'21"W), 6 ♀, 22.ix.2004; 1 ♀, 27.ix.2004.

Pison sp. 2

Distribution.—For general comments on the genus see previous species. First record of this smaller species for the Cook Islands. Probably indigenous.

Biology.—See previous species.

Specimens examined.—Rarotonga: Arorangi, Raemaru trail, 50 m (21°14'06"S 159°49'19"W), 3 ♀, 3 ♂, 17.ix.2004; Arorangi, upper beach, 5 m (21°12'45"S 159°49'39"W), 1 ♀, 20.ix.2004; 4 ♀, 21.ix.2004.

Tachysphex famiensis famiensis Cheesman, 1928

Distribution.—New Caledonia, Loyalty Islands, Society Islands, Tuamotu Archipelago, Marquesas. The subspecies *T. f. howeanus* Pulawski, 1977 is only known from Lord Howe Island and *T. f. corallinus* Pulwaski, 1977 occurs on the north and east coast of Australia, New Guinea and the Solomon Islands (Pulawski 1977). A female was collected in 1925 on a ship about 750 km SE of Pitcairn flying over a bulwark (Pulawski 1977). Obviously *T. f. famiensis* can be easily introduced to other islands. Indigenous to the Cook Islands.

Earlier records are from Rarotonga (1977, 1979, leg. Krauss; ii.2003, leg. G. McCormack) and Mauke (1976, leg. Krauss) (McCormack 2004).

Biology.—This species is very common on sandy and rocky parts of the upper beach where it nests in the ground or in existing cavities of rocks. It can also be

frequently found in sparsely vegetated places further inland. Females prey upon cockroaches which sit exposed on leaves (Pulawski 1977). Males often visit the introduced Mexican Fire-Plant (*Euphorbia cyathophora* J.A. Murray) (Euphorbiaceae) for nectar.

Specimens examined.—Rarotonga: Arorangi, upper beach, 5 m (21°14'20"S 159°49'40"W), 8 ♀, 12 ♂, 15.ix.2004; Arorangi, Raemaru trail, 50 m (21°14'06"S 159°49'19"W), 2 ♂, 17.ix.2004; Arorangi, upper beach, 5 m (21°12'45"S 159°49'39"W), 3 ♀, 7 ♂, 20.ix.2004; 1 ♂, 21.ix.2004; 1 ♀, 2 ♂, 4.x.2004; Mangaia: Ivirua, Taro gardens, 30 m (21°55'20"S 157°53'53"W), 1 ♀, 10 ♂, 23.ix.2004.

Megachilidae

Lithurgus (*Lithurgus*) *scabrosus* (F. Smith, 1859)

Distribution.—India, Indonesia, New Guinea and many Pacific Islands eastwards up to Tahiti (Michener 1965, Snelling 2003). Due to their nesting in wood these bees have an excellent ability to cross water barriers, e.g. on ships (Michener 1965). Probably introduced to the Cook Islands by ancient Polynesians.

Previous records are from Rarotonga (iii.1979, leg. N.L.H. Krauss) and Aitutaki (1977, leg. N.L.H. Krauss) (McCormack 2004).

Biology.—Six of the seven collected specimens carry the phoretic mite *Chaetodactylus ludwigi* (Trouessart, 1904), some of them in large amounts. This mite is known from *Lithurgus* species from Madagascar, India, Java, New Caledonia, Moorea Island near Tahiti and Eastern Caroline Islands (Fain and Pauly 2001). I found *L. scabrosus* nesting in decaying wooden poles and like Pauly & Munzinger (2003) I observed a female visiting an *Ipomoea* species – Coastal Morning-Glory (*Ipomoea littoralis* Blume) (Convolvulaceae). Species of this subgenus are known to be oligoleges of Malvaceae (such as the widely distributed *Hibiscus*) (Snelling 2003) and Convolvulaceae (such as *Ipomoea pes-caprae* (L.) Sweet, a widely distributed plant on pantropical seashores) (Pauly et al. 2001).

Specimens examined.—Rarotonga: Arorangi, upper beach, 5 m (21°12'45"S 159°49'39"W), 2 ♀, 20.ix.2004; Mangaia: S Ivirua, on Makatea, 30 m (21°55'52"S 157°52'42"W), 1 ♀, 26.ix.2004; Ivirua, on Makatea, 30 m (21°55'15"S 157°53'21"W), 4 ♀, 27.ix.2004.

Megachile (*Callomegachile*) *umbripennis* F. Smith, 1853

Distribution.—Widely distributed in Southeast Asia and large parts of the South Pacific (Krombein 1950, Snelling 2003). In Hawaii it was present as early as mid-19th century suggesting an introduction by Polynesians prior to European arrival (Snelling 2003). Probably introduced to the Cook Islands by ancient Polynesians (Pauly and Munzinger 2003).

Previous records are from Rarotonga (iii.1979, leg. N.L.H. Krauss; 1999, leg. British Executive Service Overseas), Atiu (1976, leg. N.L.H. Krauss), Aitutaki (1960, 1977, leg. N.L.H. Krauss; Krauss 1961) and Pukapuka (ii.2004, leg. G. McCormack) (McCormack 2004).

Biology.—One female and three males carry some phoretic mites. This species nests in all kinds of cavities of suitable size but with a preference for wood. Plant resins are used to line the nest cells (Snelling 2003). This species is perhaps oligolectic on Fabaceae. The few observed females frequently visit the native Beach Pea (*Vigna marina* (Burm.)). Males regularly visit the flowers of the introduced Mexican Fire-Plant (*Euphorbia cyathophora* J.A. Murray) (Euphorbiaceae) for nectar.

Specimens examined.—Rarotonga: Arorangi, upper beach, 5 m (21°14'20"S 159°49'40"W), 15 ♂, 15.ix.2004; 1 ♀, 5 ♂, 18.ix.2004; Arorangi, fallow land, 10 m (21°12'54"S 159°49'42"W), 1 ♀, 19.ix.2004; Arorangi, upper beach, 5 m (21°12'45"S 159°49'39"W), 2 ♀, 3 ♂, 20.ix.2004; 3 ♂, 21.ix.2004; Mangaia: Ivirua, on Makatea, 30 m (21°55'15"S 157°53'21"W), 1 ♂, 22.ix.2004; S

Ivirua, on Makatea, 30 m (21°55′52″S 157°52′42″W), 1 ♀, 1 ♂, 26.ix.2004.

Megachile (*Eutricharaea*) sp. 1

Distribution.—From the Australian and South Pacific region 66 taxa of the subgenus *Eutricharea* are described that can be divided into three groups (Michener 1965). This small species belongs to group A as defined by Michener (1965). It comprises 36 taxa that are badly in need of revision before the species can be identified. The male is characterised by a mandible with an inferior basal projection, front coxa with apical spine, anterior tarsus slightly broadened and carina of sixth tergum with median emargination almost obscured by coarse serration. *Eutricharea* is widely distributed in the South Pacific with at least some species indigenous to its islands. First record for the Cook Islands of this possibly indigenous species.

Biology.—The males were patrolling the upper beach over sparsely vegetated areas covered with the native Beach Pea (*Vigna marina* (Burm.)) (Fabaceae). Most species of the genus *Megachile* make nest cells from pieces cut from leaves of plants (Michener 1965); others line their cells with plant resins (Michener 2000).

Specimens examined.—Rarotonga: Arorangi, upper beach, 5 m (21°12′45″S 159°49′39″W), 1 ♀, 4 ♂, 20.ix.2004; 3 ♂, 21.ix.2004; 3 ♂, 4.x.2004.

Megachile (*Eutricharaea*) sp. 2

Distribution.—As for the previous species, this one belongs to group A of Michener (1965). This species is unusually large (female 11–13 mm, male 10–12 mm) for a member of group A. The male is characterised by a mandible without an inferior basal projection, front coxa with short apical tubercle, anterior tarsus unmodified and carina of sixth tergum with large median emargination. For general comments on the distribution of *Eutricharaea* see previous species. First record for the Cook Islands. Perhaps introduced.

Biology.—One male carries a few individuals of a phoretic mite. For data on nesting see previous species. This species is very probably oligolectic on Fabaceae. The females can be regularly observed to collect pollen on the native Beach Pea (*Vigna marina* (Burm.)) and sometimes on the introduced Streaked Rattlepod (*Crotalaria pallida* Aiton).

Specimens examined.—Rarotonga: Arorangi, upper beach, 5 m (21°14′20″S 159°49′40″W), 1 ♀, 15.ix.2004; Arorangi, upper beach, 5 m (21°12′45″S 159°49′39″W), 14 ♀, 3 ♂, 20.ix.2004; 11 ♀, 5 ♂, 21.ix.2004; 5 ♀, 3 ♂, 4.x.2004; Mangaia: Ivirua, on Makatea, 30 m (21°55′15″S 157°53′21″W), 6 ♀, 2 ♂, 22.ix.2004; 1 ♀, 2 ♂, 27.ix.2004; Ivirua, Taro gardens, 30 m (21°55′20″S 157°53′53″W), 1 ♀, 1 ♂, 23.ix.2004.

Apidae

Apis mellifera Linnaeus, 1758

Distribution.—Now distributed worldwide and introduced to the Cook Islands. It probably occurs on all larger islands and is known from Rarotonga, Mangaia, Aitutaki and Atiu and definitely missing on Tongareva (= Penrhyn) and Pukapuka (Krauss 1961, McCormack 2004).

Biology.—The honeybee is highly social and polylectic. Beside the hives of beekeepers it can build nests in hypergaeic cavities like hollow trees.

Specimens examined.—

Ceratina (*Neoceratina*) *dentipes* Friese, 1914

Distribution.—Japan, southeast Asia, Australasia and the West Pacific. The Cook Islands are far outside of the known distribution of *C. dentipes* and the subgenus *Neoceratina* on the whole (Michener 1965, Hirashima 1971). The species is recorded for the first time on the Cook Islands and is surely introduced.

Biology.—The species is known to build nests in pithy stems. Nesting biology is

Table 1. Distribution of bees and wasps for each island in the Cook Islands. Data about island type, land area and maximum elevation after Hein et al. (1997). Codes for islands and abbreviations are as follows: PN: Penrhyn, RK: Rakahanga, MH: Manihiki, PK: Pukapuka, NS: Nassau, SW: Suwarrow, PL: Palmerston, AK: Aitutaki, MN: Manuae, MT: Mitiaro, TK: Takutea, AT: Atiu, MK: Mauke, RR: Rarotonga, MG: Mangaia; A: Atoll, R: Reef Island, M: Makatea, V: High Volcanic Island, n.a.: no data available.

	Northern Cook Islands						Southern Cook Islands								
	PN	RK	MH	PK	NS	SW	PL	AK	MN	MT	TK	AT	MK	RR	MG
Island type	A	A	A	A	R	A	A	A/V	A	M	R	M	M	V	M
Land area (km²)	9.8	3.9	5.4	3.8	1.1	0.4	1.1	18.0	5.8	30.0	1.4	29.0	18.0	67.0	51.0
Max. elevation (m)	low	low	5	6	9	low	low	124	9	11	6	70	24	653	169
Species															
Chrysis spec.														X	
Anterhynchium rufipes								X				X		X	X
Delta esuriens okinawae														X	X
Pachodynerus nasidens				X				X				X		X	X
Parodynerus bicinctus								X		X		X		X	X
Polistes jokahamae								X				X		X	X
Polistes olivaceus														X	X
Ampulex compressa														X	
Pison spec. 1				X				X						X	X
Pison spec. 2														X	
Sceliphron caementarium								X						X	
Sceliphron laetum														X	
Tachysphex f. fanuiensis													X	X	X
Apis mellifera								X				X		X	X
Ceratina dentipes														X	
Lithurgus scabrosus								X						X	X
Megachile umbripennis				X				X				X		X	X
Megachile spec. 1														X	
Megachile spec. 2														X	X
Total species no.	n.a.	n.a.	n.a.	3	n.a.	n.a.	n.a.	9	n.a.	1	n.a.	6	1	19	12

analysed in detail by Okazaki (1992). The bee was found nesting in twigs in a small forest clearing in the interior of Rarotonga and on the upper part of the beach where it was flying above the creepers of the Beach Pea (*Vigna marina* (Burm.)) (Fabaceae).

Specimens examined.—Rarotonga: Arorangi, Raemaru trail, 50 m (21°14′06″S 159°49′19″W), 5 ♀, 17.ix.2004; Arorangi, upper beach, 5 m (21°12′45″S 159°49′39″W), 2 ♀, 21.ix.2004.

DISCUSSION

Fauna and biogeography of the Aculeata of the Cook Islands.—Information about the bee and wasp fauna is only available for seven of the fifteen Cook Islands (Table 1). No records exist for the islands of Palmerston, Manuae and Takutea in the Southern Group and Penrhyn, Manihiki, Rakahanga, Nassau and Suwarrow in the Northern Group. During my three weeks' stay on Rarotonga and Mangaia six species were recorded for the first time (*Pison* sp. 2, *Sceliphron laetum*, *Ceratina dentipes*, *Megachile* sp. 1, *M.* spec. 2) adding up to a total of 19 species of bees and aculeate wasps currently known from the Cook Islands. Except for the probably extinct *Ampulex compressa* and *Chrysis* sp. all previously collected species were recorded again. Among the newly recorded species are the conspicuous wasp *Sceliphron laetum* and the large and common bee *Megachile* sp. 2. This is a clear sign that further investigations especially on the outer islands will probably lead to the discovery of additional species.

From their biology and distribution it is concluded that probably only three species

are definitely indigenous to the Cook Islands: *Anterhynchium rufipes*, *Parodynerus bicinctus*, *Tachysphex fanuiensis*. All of them are widely distributed in the tropical Pacific. Three more species (*Pison* sp. 1, *Pison* sp. 2, *Megachile* sp. 1) might be indigenous or even endemic because many of their relatives are known to be restricted to other Pacific islands (Yasumatsu 1953, Michener 1965). But their status remains uncertain due to the lack of revisions. Of the remaining 13 species 11 were accidently introduced. The origin of eight species is in southeast Asia, two were introduced from the Americas and the provenance of *Chrysis* spec. is unknown. All these species build their nests overground in pre-existing cavities, dead wood and pithy stems, construct free clay nests or free hanging paper nests. The only exception is the cuckoo wasp *Chrysis* sp. that very probably parasitises a wasp species with hypergaeic nests. Thus, the nests are easily transported and species have been carried to various islands (Michener 1965). Of the six possibly indigenous species five build overground nests, too, and only *T. fanuiensis* is a ground nester. In addition to the honeybee only the digger wasp *A. compressa* was intentionally introduced to control the cockroach *Periplaneta americana* (Walker and Deitz 1979). With increasing tourism and trade accidental introductions of additional species can be expected in the future.

For the comparatively well investigated islands Pukapuka, Aitutaki, Mangaia and Rarotonga a positive relationship exists between island size and number of species (Table 1) as predicted by the theory of island biogeography (MacArthur and Wilson 1967). But this relationship is probably artificial and caused by accidental introductions. Except for the very touristic Aitutaki the other three islands show a correlation of species diversity and intensity of traffic that facilitates introductions. While the intensity of faunistic surveys on Aitutaki is low compared with the aforementioned islands further investigation might show that the real number of species on this island is much higher than the nine recorded species and that it would fit into this scheme as well. A lack of correlation between species diversity and size of an island could also be predicted from the low number of (probably) indigenous species that indicates an undersaturation of its fauna, probably due to their isolation.

Biogeography of the aculeate fauna of Pacific islands.—The biogeography of the bee and wasp fauna of the Cook Islands can only be understood in a Polynesian and Pacific context. Traditionally the Pacific islands, excluding those close to the Americas, Asia and Australia, are divided, originally on the basis of their indigenous aboriginal peoples, into Polynesia, Micronesia and Melanesia (Crocombe 2001). This division serves sufficiently for biogeographic purposes (Fosberg 1984) and is used here, too. Good accounts of the bees and wasps are available for very few of the Pacific islands or island groups (Table 2). Therefore, biogeographic conclusions on their island faunas must be regarded as tentative except at the broadest level.

From Polynesia faunistic data on bees and wasps are available for seven archipelagos including New Zealand. The most comprehensive investigations were made on six islands groups of Micronesia whilst Melanesia is poorly investigated (Table 2). As demonstrated for Micronesia (Krombein 1950) there is a general tendency that the number of species as well as endemics of Pacific islands declines with increasing distance from Australian and Asian mainlands and the Indo-Australian islands. Thus, most of the remote archipelagos of Polynesia possess a depauperate aculeate fauna consisting of widespread species. This, too, applies to the indigenous aculeate fauna of the Cook Islands that is extremely depauperate and only consists of three wasp species widely distributed in Polynesia and other parts of Oceania. Due to a lack of taxonomic revisions the

Table 2. Numbers of (sub)species of aculeate wasps and bees (including introduced species) in Polynesia and adjacent islands of Melanesia and Micronesia (n.a.: no data available; (): species numbers for some families not available).

	Apidae	"Sphecidae"	Vespidae	Pompilidae	Scoliidae	Mutillidae	Tiphiidae	Chrysididae	total	endemic	introd.
Polynesia											
Hawaii [1)2)3)]	75	60	127	4	1	-	5	3	275	76%	24%
Samoa [4)5)6)]	13	9	3	1	-	-	-	-	26	n.a.	n.a.
Marquesas Is.[7)22)23)]	1	7	4	-	-	-	-	-	12	-	n.a.
Tuamotu Is.[22)23)]	2	1	3	-	-	-	-	-	6	-	n.a.
Society Is.[22)23)25)]	3	11	7	-	-	-	-	-	21	5%	n.a.
Cook Is.	6	6	6	-	-	-	-	1	19	-	84%
New Zealand [8)27)28)]	>40	23	n.a.	11	n.a.	n.a.	n.a.	n.a.	(74)	(±80%)	n.a.
Melanesia											
Solomon Is. [9)10)]	32	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	(32)	n.a.	n.a.
Vanuatu [11)12)13)]	14	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	(14)	n.a.	n.a.
New Caledonia [14)21)24)26)]	22	19	6	12	1	1	2	-	63	n.a.	n.a.
Fiji [15)16)]	10	15	6	5	2	-	-	-	38	n.a.	n.a.
Micronesia											
Bonin Is. [17)29)]	8	4	2	-	1	1	-	1	17	47%	6%
Northern Marianas [18)19)20)]	6	3	3	-	-	-	-	-	12	25%	42%
Southern Marianas [18)19)20)]	14	12	7	2	1	-	-	-	36	39%	42%
Carolines [18)19)20)]	16	21	5	2	3	1	-	-	48	50%	25%
Marshall Is. [18)19)20)]	2	8	1	-	-	-	-	-	11	-	55%
Gilbert Is. [18)]	-	1	-	-	-	-	-	-	1	-	100%

[1)] Snelling (2003), [2)] Daly & Magnacca (2003), [3)] Nishida (1994), [4)] Pauly & Munzinger (2003), [5)] Perkins & Cheesman (1928), [6)] Williams (1928), [7)] Williams (1932), [8)] Donovan (1983), [9)] Krombein (1949a), [10)] Krombein (1951), [11)] Cheesman (1936), [12)] Cheesman & Perkins (1939), [13)] Cheesman (1948), [14)] Pauly & Munzinger (2003), [15)] Williams (1947), [16)] Fullaway (1957), [17)] Yasumatsu (1955), [18)] Krombein (1949b), [19)] Krombein (1950), [20)] Tadauchi (1994), [21)] Callan (1990), [22)] Michener (1965), [23)] Cheesman (1928), [24)] Turner (1919), [25)] Menke (1979), [26)] Williams (1945), [27)] Harris (1987), [28)] Harris (1994), [29)] Yasumatsu (1936)

recorded species of *Pison* and *Megachile* (*Entricharaea*) are unidentifiable at present but they are probably not endemics of the Cook Islands. Exceptions are Hawaii with its highly endemic and species rich fauna that result from the adaptive radiation of genera like *Hylaeus* (*Nesoprosopis*) (60 species) and *Odynerus* (99 species) and the incompletely documented fauna of New Zealand. There is also a rapid eastwards loss of indigenous parasitic taxa of the families Scoliidae, Mutillidae, Tiphiidae and Chrysididae. They are all dependent on their hosts and thus have a limited potential for dispersal. Interestingly, this also seems to be true for the spider hunting Pompilidae.

These basic patterns are nowadays at least partly obscured by the number of introduced species that often comprise up to 50% or more of the species known to occur on some archipelagos (Table 2). As a basis for the reconstruction of distribution patterns and to better understand the history of island colonization in the Pacific there is a need for further investigations of island faunas and taxonomic revisions of at least the most diverse and widely distributed genera of bees and sphecid wasps.

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